NERRS Science Collaborative
Progress Report for the Period 03/01/12 through 09/01/12
Submitted September 5, 2012

Project Title:

Sustaining Coastal Landscapes and Community Benefits:
Developing an Interdisciplinary Model for Enhancing the Impact of NERRS Science

Principal Investigator(s): Dr. Christine Feurt & Dr. Robert Johnston

Project Investigators Wells NERR Science Collaborative Team
Dr. Christine Feurt (Science Integrator), Dr. Michele Dionne, Tin Smith, Suzanne Kahn Eder, Jeremy Miller, Jake Aman, Sue Bickford, Annie Cox, Hannah Wilhelm, Zack Steele, Katie Hill

Titles:
Coastal Training Program Coordinator (CTP), Research Director, Stewardship Coordinator, Education Director, Research Associate, Research Associate, GIS Specialist, CTP Associate, Research Intern, CTP Fellow, Sustainability Intern

Project Research Team
This interdisciplinary team designs and conducts economics, ecological and communication research in collaboration with stakeholders.
Co-Principal Investigator Dr. Christine Feurt, CTP Coordinator, Wells NERR & Director Center for Sustainable Communities University of New England
Co-Principal Investigator: Dr. Robert Johnston, Director, George Perkins Marsh Institute and Professor, Department of Economics Clark University
Dr. Michele Dionne, Research Director, Wells NERR
Dr. Verna DeLauer, Research Scientist, George Perkins Marsh Institute, Clark University
Dr. Mahesh Ramachandran, Research Associate, George Perkins Marsh Institute, Clark University
Mr. Ben Holland, PhD student, George Perkins Marsh Institute, Clark University
Mr. Peter Wiley, Economist, NOAA Coastal Services Center

Project start date: Fall 2010

Report compiled by: Christine Feurt and Project Research Team
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Contributing team members and their role in the project:
See above for Wells NERR Science Collaborative Team and Project Research Team composition

Wells NERR Stakeholder Network These 18 organizations participated in the development of the proposal. Representative members of the network interacted with the Wells NERR or Project Research Team during this reporting period to provide feedback on research progress and incorporation of results in conservation, management and planning.

1. Maine Association of Conservation Commissions

2. Maine Geological Survey
3. Maine Coastal Program
4. Maine Nonpoint Education for Municipal Officials (NEMO)
5. Maine Sea Grant
6. Maine Drinking Water Program
7. Maine Department of Inland Fisheries and Wildlife, Beginning with Habitat
8. Maine Department of Environmental Protection
9. Maine Department of Marine Resources
10. Southern Maine Regional Planning Commission
11. Mt A to the Sea Conservation Initiative
12. Rachel Carson National Wildlife Refuge
13. University of New England
14. Laudholm Trust
15. Piscataqua Region Estuaries Partnership
16. Town of Wells, Planning Department
17. Town of Sanford, Planning Department
18. Town of Kennebunk, Conservation and Open Space Planning Committee & Planning Department

A. **Progress overview**:

Overall Goal of Project

The proposed project will develop and apply an integrated, spatially-explicit, transdisciplinary framework to characterize and quantify the impact of riparian management on ecosystem services identified as important by Wells NERR stakeholders including land use decision makers, planners and policymakers at state and municipal governmental scales and partner NGOs. Building on ecological models and data available for the Merriland River and Branch Brook watersheds adjacent to the Wells NERR, the project will coordinate economic expertise in ecosystem service valuation with Wells NERR expertise in ecological science to provide defensible estimates of social benefits associated with riparian area management in the Wells NERR region, as realized through changes in ecosystem services. Quantification of values and tradeoffs associated with management alternatives will provide information crucial for policy design and to identify often overlooked benefits of policies to enhance ecosystem sustainability. Integrated components of the proposed project will ensure that science-based results are applied effectively to inform coastal management and land use decisions and that the results are transferrable to other Reserves. Outputs will provide heretofore unavailable mechanisms through which NERRS ecological data can be integrated with economic data and used in coordination with stakeholders to inform coastal management that sustains ecosystem services associated with riparian areas.

Overall Project Objectives

I. Develop a user-inspired, transdisciplinary model to guide sustainable riparian management in the Wells NERR and surrounding watersheds, grounded in geo-spatially explicit quantification of ecological/economic tradeoffs in ecosystem services and values.

II. Coordinate social science and cognitive theory, principles of effective communication, local motivations for stewardship/conservation, and approaches for social learning to:

a. Identify specific stakeholders most influential in affecting decisions, management and policy change affecting Wells NERR riparian areas addressed in Objective I.

b. Evaluate Wells NERR communication approaches to these identified stakeholders/stakeholder groups to assess the degree to which messages are in alignment with values and priorities identified in Objective I;

c. Develop high impact, science-based communication strategies and decision support tools—based on the ecological/economic results of Objective I—to inform integrated management of riparian area land use, habitat and nonpoint source pollution in watersheds draining into the Wells NERR region.

III. Engage Wells NERR stakeholders, the Science Collaborative Team and the Project Research Team within a collaborative learning process to build long-term institutional and regional capacity for improved riparian management through a community of practice. Collaborative learning will be grounded in coordinated science, communication and decision support outputs of Objectives I and II.

IV. Based on results of prior objectives, develop transferable templates for application of developed methods to guide policy development and stakeholder interactions in other Estuarine Reserves. Integrate with NERRS/NOAA to assist in broader adoption.

Focus of Objectives for the period March 2012 – September 2012

Project Timeline Highlighted for this Reporting Period

Objectives, Products, Activities	Year 1					Year 2						Year 3		
	Q1	Q2	Q3	Q4		Q1	Q2	Q3	Q4		Q1	Q3	Q3	Q4
Objective I: Develop Models Quantifying Ecosystem Services and Values	x	x	x	x		x	x	x	x		x	x		
Objective I: Develop, Test and Implement Choice Experiment; Conduct Ecological Field Campaigns; (Finalize Model Linkages –not during this period)			x	x		x	x	x	x		X	x		
Objective I: Data Analysis and Results for Ecological/Economic Models						x	x	x	x		x	X		
Objective II: Communications Audit		x	x	x		x	x	x	x					
Objective II: Mental Models and Test Cases				x		x	x	x	x		x	x		
Objective III: Develop Community of Practice	x	x	x	x		x	x	x	x		x	x	x	x
Objective IV: Develop/Disseminate Decision Support Tools and Transfer Mechanisms											x	x	x	x
Objectives I-IV: Coordinate with Stakeholders	x	x	x	x		x	x	x	x		x	x	x	x

B. Working with Intended Users: Presentations, outreach and engagement about the project, ecosystem services, collaborative interdisciplinary research

Interaction with intended users/stakeholders during this period is described below. The collaborative team for this project engages with stakeholders at conferences, workshops, field based trainings, meetings and as members of on-going partnerships such as the Salmon Falls Watershed Collaborative, the Mount A to the Sea Conservation Initiative and the newly formed (2011) Southern Maine Water Learning Network and Mobilize Maine Partnership. The events provide opportunities for building trust, creating awareness of the project and staying current on organizational priorities to maintain the relevance of the project and increase the potential for transfer of research findings. Formal evaluations, meeting minutes, participant observation and individual conversations with people in the activities listed above provided input into the project. Members of the project teams use these regular stakeholder interactions to guide the project, build trust and create new partnerships.

During this period individual stakeholder interviews were conducted by DeLauer and Holland to inform design of the choice experiment survey and mental models component of the communication research. By default, through the mental modeling interviews thus far, we have reached out to intended users. Some interviewees are also considered intended users such as those affiliated with municipal government. Because of the interview experience, they are more informed about our project's goals and objectives and potential relevance to their professional interests. During this period mental models interview questions were tested and adapted based upon initial findings. The original sample for mental models interviews will be expanded to increase the diversity of the pool of interviewees. Thirty interviews is the goal for this portion of the project. The next six months will be an intense period for interviews with the majority of the 30 interviews being completed.

Ben Holland contacted one of the town planner stakeholders to get information on the different riparian buffer policy attributes. He learned that it is almost impossible, with current regulations and enforcement, to discover riparian land zoning violations. Even when they are discovered people don't generally pay fines. There is not a set fine schedule. It is decided by the town planning board what fines should be imposed and almost any excuse is accepted. This has led to the creation of the "Land Inspections" attribute and the extension of the "No Development Zone" around rivers as the secondary policy attribute as mentioned above. He also contacted the team from the Maine Healthy Beach Initiative to determine the beach quality attribute. The team from the Maine Healthy Beach Initiative is generating data which will be used to determine the beach water quality attribute this fall.

The Wells NERR CTP Advisory Committee met on March 27, 2012 to discuss and revise the CTP Strategic Plan for the period 2012 – 2017. Review of the Sustaining Coastal Landscapes and Community Benefits project was on the agenda. The advice of both the Advisory Committee and the Estuarine Reserve Division reviewing the plan was to include the approach being used for the project in future planning for CTP. Most of the members of the CTP Advisory Committee are key stakeholders on the project. Members of the CTP Advisory Committee are the Education and Outreach Specialist for the Maine Coastal Program; Senior Planner of Southern Maine Regional Planning Commission (SMRPC); University of Maine Sea Grant Extension Specialist; President of Laudholm Trust; Coordinator for Maine Nonpoint Education for Municipal Officials (NEMO); Coordinator of the Maine Beginning with Habitat Program; and Director of the Maine Drinking Water Program.

Members of the Wells NERR Collaborative Science Team including Christine Feurt, Annie Cox and Tin Smith are actively engaged in the Salmon Falls Watershed Collaborative. This partnership of governments, watershed groups, land trusts and water supply agencies includes stakeholders engaged in developing and implementing the NERRS Science Collaborative Project. On Earth Day, April 23, 2012 at a ceremony at EPA Headquarters in Washington, DC, the Salmon Falls Watershed Collaborative was awarded the US Water Prize for 2012 by the US Clean Water America Alliance. The Collaborative was recognized for their innovative work developing strategies for sustaining watershed ecosystem services through partnerships. Members of this robust stakeholder network are key intended users for the results of this project.

Kathryn Rosengren presented *Graduate Internship Final Presentation*. Summary of internship contribution to Science Collaborative project, including results of policy analysis and stakeholder engagement to evaluate riparian buffer policies. Presentations made to TIDES and UNH graduate students and faculty in a capstone seminar at UNH in May. Kathryn was TIDES Graduate Fellow working as an intern on the Wells NERR project. 17 participants.

Annie Cox and Zack Steele represented the Wells NERR Mobilize Maine Regional Meetings and the HUD Sustainable Communities "Sustain Southern Maine" project during this period. An economic development initiative for southern Maine business leaders, academics, local governments and NGOs focusing on sustainability, quality of place and economic development. Representatives for southern Maine businesses, financial organizations, municipal government and NGOS are part of this working group.

Zack Steele developed and implemented: *Lessons in the Landscape: Sanford's Significant Headwaters,* June 29, 2012. This field based workshop developed with the Town of Sanford focused on approaches being used in the watersheds for the project to restore watershed structure and function through brownfields redevelopment, pollution abatement and streambank restoration.12 participants.

Hannah Wilhelm, with the assistance of Sustainability Intern Katie Hill, coauthored a brochure about the project to engage landowners living adjacent to the study sites being used for the ecological research. Hannah created a database of all adjacent landowners and developed the brochure in response to requests to learn more about the science and the results. People are especially interested in fish species and those are highlighted in the brochure.

Chris Feurt, in partnership with John Leach of the South Berwick Water District presented *Collaborative Watershed Management* to the Maine Drinking Water Program annual staff retreat August 16, 2012. 35 participants.

Chris Feurt conducted a facilitated session on August 15, 2012 with the York Water District and Mt A to the Sea to develop strategies for collaborative work between land trusts and water districts. A larger meeting of Board Members of each group is scheduled for October. This work aligns with work in the Branch Brook watershed to conserve ecosystem services for drinking water through partnerships.

Wells NERR and UNE Researchers and stakeholders participated in *"We're All in the Same Boat" How Planning, Restoration, Research and Management are Sustaining the Saco*, August 17, 2012. Saco Estuary Policy, Science and Stewardship Boat Trips hosted for stakeholders working in the estuary portion of the Saco in Biddeford and Saco. Stakeholders and researchers are all in the same boat because the work we do, the places we care about and our professional goals are connected to the health of ecosystems. The August boat trip on the Saco gave researchers and stakeholders a chance to observe and discuss the way a group of researchers, students, planners, managers and community leaders are collaborating to understand and sustain what they value about the Saco estuary and its watershed.

Katie Hill, Sustainability Intern, participated in Saco River stakeholder meetings (Planning Board meetings and Saco River Corridor Commission), prepared blog posts and assisted Hannah Wilhelm in the development of a property owner brochure about the project.

Southern Maine Water Resources Learning Team July 11, 2012 attended by Zack Steele. Review of a proposed plan for a Water Network in southern Maine. The work of the group is in alignment with the Science Collaborative project and offers a useful way to connect the project to a larger stakeholder network.

Members of Wells NERR Science Collaborative Team conducted, TIDES Field Orientation to the NERRS. This graduate field-based Seminar for students in the UNH TIDES (Training for the Integration of Decision-making and Ecosystem Science) program focused on the work of the Reserve system including the collaborative research. Aug 22, 2012. Eight UNH graduate students and faculty.

Interactions with ecological scientists as intended users. During this period the ecological team working at the Wells Reserve had questions about how the ecological data would be used in developing the choice survey. These questions were precipitated by the unfortunate loss of Dr. Michele Dionne to cancer. Research Associates tasked with field research were trust into the position of having to both collect and synthesize data and lack of knowledge about how the data connected to the larger interdisciplinary goals of the project. This response will no doubt be repeated as the methods developed by this project are disseminated to ecological scientists in the system and remain to be dealt with during the next six months.

Stakeholder interactions during the next six months will include continued work with partners highlighted above through meetings, trainings, and conference calls. Mt A to the Sea has been on hiatus pending the hiring of a new Director anticipated in late September. Interviews will continue for both the choice survey and mental models research. Interactions with the NERRS community will take the form of a webinar of Dr. DeLauer's work, an on-line qualitative methods course being developed this fall, participation in the NERRS Annual Meeting where Pete Wiley and Chris Feurt will participate in a session and a training session presented by Chris Feurt on Collaborative Learning applications in the NERRS System

C. Progress on project objectives for this reporting period

The Research Team members met on August 8th to review project timeline, evaluate stakeholder input during this period and to adapt methods and timeline based on input. The group decided to meet monthly by conference call to coordinate the interdisciplinary aspects of the project – especially the design of the choice experiments based upon ecological data.

Objective 1. Develop a user-inspired, transdisciplinary model to guide sustainable riparian management in the Wells NERR and surrounding watersheds, grounded in geo-spatially explicit quantification of ecological/economic tradeoffs in ecosystem services and values.

Task I.1. Develop Ecological Scenarios and Characterize Biophysical Status, Trends and Responses.

The overall goal of the ecology portion of this project is to determine the influence of forested riparian buffer on aspects of stream ecology – specifically nitrate and ammonium inputs and water column concentrations; water temp, pH, turbidity and level; algal cover on substrates; stream macro invertebrates; in-stream fish habitat, in-stream flows, and fish.

We accomplished all of our planned work for the 2012 field season: 1) Cofirm permission to access 20 field sites, communicate with landowners during field work and respond to requests for information by creating a landowner information brochure 2) deployment, collection and processing of long-term nitrogen nutrient collectors just subsurface in the streamside soils in our 20 sampling sites (5 open and forested pairs in each watershed), 3) concurrent deployment of 2 YSI 6600-V2 water quality data loggers with nitrate probes for 24-72 hours at each paired site; and for the same 3 paired sites in each sub watershed (Merriland River and Branch Brook), 4) construction, deployment, retrieval and processing of standardized “rock bags” for collecting stream macroinvertebrates and calculation of Macroinvertabrate IBI following Massachusetts State procedures, 5) field test of Maine State stream macroalgal cover (very little suitable substrate at our field sites), 6) electrofishing to sample fish community (id, total length and weight), 7) fish habitat and in-stream flow measurements.

Field session methods have been described by Research Associates and are included as an appendix to this report.

Task I.2. Characterize Linkages between Ecological Outcomes, Ecosystem Services and Values.

Task I.3 Develop Models for Estimation of Ecosystem Service Values and Tradeoffs.

Task I.4. Develop and Test Choice Experiment Surveys.
Project update from Ben Holland, PhD student Clark University

- I joined the project in May, 2012 and since then my main goal has been to get up to speed on the survey design and attributes. To this regard, I have worked with Mahesh to take over his portion of the project and made major revisions to the survey to make it ready for focus groups. The data I am in the process of collecting is the beach water quality data, receiving brook trout data from Tin, and applying previously collected data to the survey to accurately reflect current conditions. In addition, setback information was collected and incorporated into the policy attributes of the survey.

- PhD student Ben Holland, new to the project during this period, worked with Robert Johnston to finish the revisions to the choice experiment survey to prepare for testing with a focus group in fall 2012. The goal of the survey is to calculate the willingness to pay for different final ecosystem services. There are several stages required to meet this goal. The first is to generate and understand the attributes in the survey. The current attributes are

- "Natural Riparian Land" which is a biological index of how close riparian land is to its natural state on a 0-100% scale.
- "Water Quality" which is also a biological index of how different an area of water is from its natural state on a 0-100% scale.
- "Recreational Fish" capturing brook trout numbers on a 0-100% scale.
- "Safe Swimming" capturing how often water tests exceed EPA safe water standards at area beaches on a 0-100% scale.
- "Land Inspections" is one of two riparian buffer policy attribute which will ask people if they will allow spot checks on their private land.
- "No Development Zone" is the second riparian buffer policy attributes capturing if people are willing to expand the zone around rivers where development is very restricted.

This represents progress in selecting the different attributes in the last few months but they are still volatile and subject to change depending on focus group tests the fall. The survey text and maps were reviewed by the project team during the August 8th meeting and are in revision. The survey will then be tested by focus groups and revised according to problems that arise with each iteration of focus group testing this fall. A stretch goal for this time frame will be to accurately map possible attribute changes and outcomes and generate a list of possible surveys with differing attribute values. This should only occur once the team has accepted the survey text, pictures, and format and the survey has been tested by focus groups and all alterations required are done, in essence once the survey is "finished".

- A recurring challenge: Attributes are very difficult to develop in surveys. Biological attributes must be linked to both biology and an easy to understand and evaluate number for the general public. The standard biology attribute for this survey is a score based on a 100 point index where the best possible score is a measurement at the area index site. Policy attributes are hard to develop due to the wide range of options and limited data and they need to be interesting to researchers and policy makers. This intersection of limited data but vital importance requires some thought and creativity. Focus group testing is very important to determining the quality of the different attributes and the understanding of people who are taking the survey. An attribute can be important and what the researchers assume is clearly defined, but if people taking the survey have little interest in the attribute or they do not understand what it captures, they will not evaluate it properly. This can only be determined from examining how users view the attributes through focus group testing which will occur this fall and winter.

Task I.5. Develop Sampling Plan and Implement Survey.
Task I.6. Estimate Choice Experiment Models and Forecast Household Values.

Objective 2. Coordinate social science and cognitive theory, principles of effective communication, local motivations for stewardship/conservation, and approaches for social learning to:

a. Identify specific stakeholders most influential in affecting decisions, management and policy change affecting Wells NERR riparian areas addressed in Objective I.

b. Evaluate Wells NERR communication approaches to these identified stakeholders/stakeholder groups to assess the degree to which messages are in alignment with values and priorities identified in Objective I;
c. Develop high impact, science-based communication strategies and decision support tools—based on the ecological/economic results of Objective I—to inform integrated management of riparian area land use, habitat and nonpoint source pollution in watersheds draining into the Wells NERR region.

Task II.1. Develop and Implement Communications Audit

Task II.2. Develop Mental Models and Test Cases

To date, the mental modeling team has used purposive sampling to identify an initial list of 21 potential interviewees. This list was created with the purpose of targeting individuals representative of broader interests such as from various municipal boards, land developers, and realtors. We are interested in those who have expertise in the study of and management of riparian areas and those who use these areas for personal and economic gains such as for fishing/swimming and land development. Of the 21, we received 8 positive responses and have conducted 7 of the 8 interviews as of August 23, 2012. We plan to continue to reach out to the remaining 13 individuals in September in hopes that we will be able to interview them. In addition, we will randomly target any individual from the study site who has an affiliation with a municipal board or governmental staff position, realtors, developers, and landowners. Our goal this Fall is to interview at least 30 individuals total as the first phase of our mental modeling tract.

We created an interview protocol that is designed to provoke responses that could be analyzed from both a mental modeling perspective and a consensus analysis perspective. We are using a mix of semi-structured and open-ended interview questions and a free listing technique. The free listing technique invites interviewees to list words that associate with the domain of riparian systems. We will use this information to look at any consensus among interviewees in how they characterize this domain. The mental modeling interview questions invite interviewees to explain their understanding of particular concepts and ideas related to ecosystem services in the domain of riparian systems. We will use this information to create individual mental models and identify themes across mental models. We will use the data from both the free listing and mental modeling exercises to create preliminary findings on perceptions and feelings related to the management and use of riparian areas. These findings may include perspectives about policies and policymaking, management strategies, response to authority, scientific uncertainty, individual gain and the common good and how opposing perspectives are reconciled by one individual or collectively.

Challenges include the lack of a student assistant or assistants to help with research activities.

Objective 3. Engage Wells NERR stakeholders, the Science Collaborative Team and the project's Research Team within a collaborative learning process to build long-term institutional and regional capacity for improved riparian management through a community of practice. Collaborative learning will be grounded in coordinated science, communication and decision support outputs of Objectives I and II.

(See section B above)

D. Benefit to NERRS and NOAA: List any project-related products, accomplishments, or discoveries that may be of interest to scientists or managers working on similar issues, your peers in the NERRS, or to NOAA. These may include, but are not limited to, workshops, trainings, or webinars; expert speakers; new publications; and new partnerships or key findings related to collaboration or applied science.

Impact of project from the perspective of NOAA's Coastal Services Center team member Pete Wiley based upon progress during this period:

NOAA has a broad interest in the connection between estuarine habitat and the services that these provide to society. The agency is currently in the process of creating priorities for ecosystem research based on how these translate to what is important to people. Working with groups that are addressing these issues, the project team is ensuring a connection and integration between ecological and social science research using the project process as an example. In the interagency realm, NOAA is participating in an agency response to recommendations from the President's Council of Advisors on Science and Technology related to ecosystem services. The agency response to these recommendations will include project results and will ultimately serve as a model for future work related to these recommendations.

Working Together to Get Things Done Training developed collaboratively with Wells NERR CTP and the NERRS Science Collaborative. During the period from January – August 2012 eight trainings were delivered at: Elkhorn Slough NERR, Waquoit Bay NERR, Rookery Bay NERR, Grand Bay/Weeks Bay NERR, Tijuana River NERR, Padilla Bay NERR, Old Woman Creek NERR, and North Carolina NERR. 250 participants attended the two day training. While these trainings were not funded as part of this grant they did contribute to goals of increased used of collaborative research methods in the NERRS and provided valuable insights into national challenges faced by Reserve stakeholders attempting to implement collaborative approaches. This focused interaction with the NERRS staff provided useful information that will be used to adapt the findings of this project for dissemination to the system who are key intended users for project findings.

E. Describe any activities, products, accomplishments, or obstacles not addressed in other sections of this report that you feel are important for the Science Collaborative to know.

Our project team and colleagues in the NERR System suffered a profound loss in July with the death of Dr. Michele Dionne, valued colleague, talented scientist and treasured friend. Although our loss as a research team is insignificant compared to the loss felt by Michele's family and friends, this has had and will continue to have an impact on the project for an unanticipated period of time. A new Research Coordinator will be hired in late 2012. Members of the Research and Stewardship staff at the Reserve completed field work this summer and have prepared documentation of their methods for use by a future Research Coordinator to guide the ecological portion of the project.

The greatest challenge to the project is one that may be illustrative for organizations like the NERRS where one trained scientist supervises research associates whose level of knowledge about the scope and overarching structure of a research project may differ. There is a feeling of uncertainty about the ecological portion of the project and how findings will be integrated with the economic methods. These concerns were discussed in a preliminary way among the research team on August 8^{th} and in individual meetings of research staff with Dr. Feurt. The knowledge of protocols *to collect ecological data* appears to be strong, and that aspect of the project has been documented for this reporting period in the Appendix. Research staff was asked to document methodologies specifically for this progress report. They were asked to comment on changes to methodology from what they understood to be methods identified in the original proposal, and to thoughtfully document their lessons learned with each method as if they were talking to their counterparts in another NERR who might be considering using the same methods.

Knowledge of methodology and capacity to analyze and synthesize the results of data collected are weak with Michele's passing. Concerns about integrating the ecological data in the choice experiments will be one of the priority issues for the next six months. Options being considered include inviting researchers who consulted with Michele on methodology to the Reserve to discuss results and interact with the rest of the interdisciplinary research team. Dr. Johnston is planning to meet with college doing ecosystem services work in Maine to bring their expertise to the table and increase their familiarity with our work

This loss has set the project back in our timeline. The cumulative effect that loss of the ecological team leader will have on the total project, which is interdisciplinary by design, will become easier to assess over the next few months.

<u>Annotated Appendices of Ecological Methods with Comments</u>

YSI Water Quality Monitoring Methods and Feedback
Epibenthic Algae
Benthic Macroinvertebrates
Nitrates in Runoff
Site Location Map
Stream Habitat Assessment Protocol
Stream Habitat Assessment Protocol

Sustaining Coastal Landscapes and Community Benefits Research Methods Notes: YSI Water Quality Monitoring Methods and Feedback

by Jeremy Miller- Wells NERR Research Associate, 8/21/12

<u>Intro</u>: This document aims to explain the "how, when, where, and why" of the YSI water Quality Monitoring portion of the NEERS Science Collaborative Project, as well as provide some feedback on the "pros and cons" of the sampling regime and any suggestions for moving forward for year 3 of sampling. All data from this sampling is stored on the Research Drive of the Wells NERR server under the following path; R:\MBLR NERRs Science Collaborative\Data\YSI Data. The following parameters were collected at all sites at a 15 minute sampling interval; temperature, specific conductance, salinity, pH, turbidity, depth, and Nitrate (NO_3 in mg/l). The calibration procedures and documentation are borrowed from the NERRS SWMP program water quality SOP which can be found in the following path; R:\MBLR NERRs Science Collaborative\Protocols\YSI_SOP_Ver4.2.

Two loggers were used, one for forested or buffered sites (logger #8F) and one logger for open or unbuffered sites (logger #9).

<u>Why?:</u> To collect continuous water quality data to compliment the ecological research which is occurring at each site. Also, to attempt to monitor changes in Nitrate levels on a continuous or unattended basis. Perhaps to see if increases in turbidity correlate to increased nitrate levels via runoff??

<u>2011 Methods:</u> 2011 was a bit of a learning curve for the new Nitrate probes. The period of sampling was from 6/29/11 through 8/1/11 (See "2011 checklist" spreadsheet on the server), with the exception of site 5 which was deployed in mid Sept due to Land Owner request. Each site was sampled for approximately a 3 day period with Calibration occurring between each deployment. All sites were sampled in 2011. Toward the middle of July the Nitrogen Probes began to fail sensor diagnostics during calibration which is an indication that the accuracy of the data being collected was being compromised. Exact dates can be determined from the YSI calibration sheets whose hard copies are located in the Research Offices of the CEC.

2012 Methods: In 2012 we tweaked our deployment methods a little as we found that calibrating the loggers after only 2-3 days of deployment was unnecessary. As of 2012 each data file contains data for 2 sites. The loggers were calibrated on a Monday, and deployed at the first site, then on Wednesday the loggers would be switched to the second of the 2 sites being sampled that week and retrieved on Friday so the probes could soak over the weekend in the Nitrate solution, be re-calibrated, and deployed again on the following Monday. The deployment range for summer 2012 was 7/2/12-8/2/12. We again ran into diagnostic issues with the probes after carefully following YSI procedures for their calibration and handling….

Pros, Cons, and suggestions moving forwards:

PROS:

- Using SWMP Protocol to conduct sampling assures accuracy and is a tested and accepted method of collecting high quality unattended water quality data.
- Loggers are a good investment as they can be used in the SWMP program once the project is complete and should serve the program for many years to come.
- Ability to collect multiple WQ parameters unattended at a site.
- Turbidity is a good indication of runoff occurring

CONS:

- Equipment is pricey to purchase and maintain
- Need new nitrate probes and calibration standard every year (cost)
- Nitrate probes can only be used in Freshwater
- Nitrate probes seem unreliable in their performance…very "quirky"
- Accuracy and Range of Nitrate probes seem inadequate for the environment being sampled.
- Short deployments at each site

Suggestions and thoughts:

It appears to me that the Nitrate probes are not best suited for this type of application (especially considering the associated cost to the project). The levels of Nitrate in the MBLR are very low when compared to the environments these probes are usually sampling in (waste water plants, fish hatcheries, etc). The Accuracy of +/- 2mg/l is too high in my opinion to accurately pickup the small changes in Nitrate we would expect to see in a three day period at these sites (in the absence of say a rain event). A lot of this was explained before the probes were purchased however the decision was made to go ahead anyway likely in the hopes that the probes would pick up on signals of Nitrate inputs…??

I think having the environmental parameters is important in this kind of study (Temp, turbidity, ph, etc) as they can often lend insight into the other things you're seeing in the system (fish, plants, etc), but argue that Nitrogen be captured by another method such as the resin bags or whole water grab samples that are filtered and analyzed for dissolved nutrients like we do in the SWMP program.

It seems that longer deployments would also benefit the water Quality dataset, however it makes the "period" that the data was collected at all the sites very different. That is, with longer deployments, we would start collecting at say site 1 in June and may not finish collecting at site 10 until Aug….data from June and Aug is not very comparable for this type of application. Perhaps doing a more prolonged WQ study at a choice few sites would be better than trying to capture a little data from ALL the sites…..However, for the purpose of this specific study, we should collect the same data set (perhaps minus Nitrate for year 3) at the same sites for the same period so we have 3 years of "comparable" data at least.

Research Methods Notes for Ecological Research for
Sustaining Coastal Landscapes and Community Benefits
By Hannah Wilhelm, Research Intern August 15, 2012

<u>NOTE to Research Team:</u>
Here are my notes on methods, which you asked for after the meeting
the three of you had recently. The attached document is also saved on
the server under: /Research/MBLR NERRs Science
Collaborative/Methods/mblr methods 2012 hannah.doc
Below on page 17 are my notes on changes compared to the original project proposal.
These
are also on the server at: Research/MBLR NERRs Science
Collaborative/Methods/Changes to Procedures Compared to Proposal.doc

Epibenthic Algae

What: Degraded riparian buffers can increase both sunlight infiltration to streams and nutrient inputs to streams. Nutrient input and sunlight both have an important impact on algal growth (Hill and Fanta 2008).

Where: Sites 7A, 7B, 8A, and 1A in 2011, and both A and B sites at locations 1, 2, 3, 7, 8, and 9 in 2012.

How: In 2011, a viewing bucket protocol from the Maine DEP (Danielson, 2006) was used at two of the planned six paired sites. Since this protocol requires cobble-bottom streams, it was not suitable for all study sites, and we began with a new technique in the second field season. In 2012, unglazed ceramic tiles were placed in the center of the stream channel at a maximum depth of 35 cm. (methodology was developed based on locally available materials, Chase 2010 and Barbour *et al.*). Tiles were glued to bricks to keep them in place (based on consultation with Dave Burdick), and deployed at 50, 100 and 150 feet from the start of the transects used for electrofishing surveys and fish habitat assessments, or as close to these distances as possible to achieve 35 cm or less of water depth. The standardized placement of tiles was intended to remove bias. If the exact center of the channel was more than 35 cm deep, tiles were placed as close to the center as possible. Water depth and wetted width were recorded at the site of each tile. After two weeks, the tiles were removed. Algae was scraped and rinsed off with a toothbrush and deionized water, and the resulting solution was filtered through glass fiber filters. Algae samples were processed according to the EPA procol #445, the same techniques used to measure Chlorophyll-A in the NERRS system-wide monitoring program. The filter paper holding the algal debris was frozen to burst algal cell walls and then the filter was placed in 10 mL of 90% acetone to dissolve the Chlorophyll-A from the algal debris. Chlorophyll-A concentrations were measured using Fluorimetry. The three tiles per site were considered as replicates, and their Chlorophyll-A concentration per square centimeter of tile was averaged to produce an algae growth value to compare from site to site.

Pros / Cons / Recommendations: The advantage to using artificial substrates for periphyton sampling is the uniformity from site-to-site. Some sample sites have bedrock, some have sand and clay, some have mud and logs. There is not a place algae grows that we could find reliably at every study site. A disadvantage of unglazed ceramic tiles is that they are not necessarily equivalent to naturally occuring substrates. What we are really measuring the speed at which epibethic algae colonizes, compared to the amount of epibenthic algae that's actually present. Some researchers have found unglazed ceramic tiles to equivalent to natural rocks in terms of algae colonization; others have not (Lavoie *et al.* 2004). What worked well about this method was that, in most situations, the tiles did not wash away, get scoured either by snails or the water current, and grew enough algae for us to get a Chlorophyll-A concentration reading. We did not notice a clear pattern or significant difference between "A" sites, ie. those which had an intact 100' forested buffer, and "B" sites, ie. those with a buffer that was reduced. Algal growth is controlled by nutrient levels, but also by sunlight (Hill and Fanta 2008), so we may simply have been measuring sunlight infiltration in a highly complex manner. Next year, or in future studies, I recommend quantifying canopy cover using a spherical densiometer, canopy photography, or other techinque [http://www.fs.fed.us/pnw/pubs/journals/pnw_2006_fiala001.pdf] to determine if the algal growth is primarily limited by sunlight or by nutrients. A good person to ask for recommendations is Tom Danielson, who works at the Maine DEP.

References:

Danielson, Thomas J. Protocols for Sampling Algae in Wadeable Rivers, Streams, and Freshwater Wetlands. Maine Department of Environmental Protection, June, 2006. DEPLW0634.

Chase, B.C. Massachusetts Department of Marine Fisheries. Quality Assurance Program Plan (QAPP) for Water Quality Measurements Conducted for Diadramous Fish Habitat Monitoring, Version 1, 2008-2012. Technical Report TR-42, May 2010.

Barbour, Michael T., Jeroen Gerritsen, Blaine D. Snyder, and James B. Stribling. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, Second Edition, Chapter 6. US EPA. Available at http://water.epa.gov/scitech/monitoring/rsl/bioassessment/index.cfm. EPA 841-B-99-002.

Arar, Elizabeth J. and Gary B. Collins. In Vitro Determination of Chlorophyll a and Phenophytin a in Marine and Freshwater Algae by Fluorescence. EPA method 445.0, September 1997.
Dave Burdick, Research Associate Professor, Marine Wetland Ecology and Restoration, personal communication, June 2012, Wells National Estuarine Research Reserve Coastal Ecology Center.
Hill, Walter R. and Shari E. Fanta. Phosphorus and light colimit periphyton growth at subsaturating irradiances. Freshwater Biology 53: 215–225, 2008
Lavoie, Isabelle, Warwick F. Vincent,Reinhard Pienitz, and Jean Painchaud. Benthic algae as bioindicators of agricultural pollution in the streams and rivers of southern Quebec (Canada). Aquatic Ecosystem Health & Management, 7(1):43–58, 2004.

Benthic Macroinvertebrates

What: Benthic macroinvertebrates are food for fish, and serve as sensitive indicators of water quality. Certain types of macroinvertebrates only tolerate clean, cold water, while others can survive in polluted or degraded conditions.

Where: Sites 1,2,3,7,8, and 9 in 2011 and 2012.

How: Macroinvertebrates were collected using artificial substrate samplers deployed for twenty-nine to thirty-five days, based on methods used by the Maine DEP (Davies and Tsomidies 2002). Samplers were constructed from 7.5 lbs. of #2 roofing stone and 1" mesh fabric. Several habitat parameters, including dissolved oxygen, pH, specific conductivity, wetted and bankfull width of the stream and stream flow, were recorded because they are part of the Maine DEP protocol, and could be useful for data comparisons later on. Samplers were removed from the stream using a D-frame net, and macroinvertebrates and detritus were scrubbed from the rocks with thorough rinsing in a 600 micron mesh sieve bucket, and preserved in 95% EtOH. In the lab, benthic macroinvertebrates were separated from detritus and identified to family using Merritt *et al.* 2008 as a primary reference. In 2011, the RBP-II as used by the Massachusetts DEP (Blockson, 2004; critical calculation details described in Novak and Bode, 1992) was used as an index of biotic integrity to compare "A" sites, ie. those which had an intact 100' forested buffer, and "B" sites, ie. those with a buffer that was reduced. Because of the structure of the IBI, a numerical value is only produced for "B" or impacted sites.

Pros / Cons / Recommendations: The collection, picking and identification of macroinvertebrates went well in 2011. Samples were picked through twice in the lab to make sure macroinvertebrates were found. In 2012, we added rose bengal dye, which stains animal tissue but not plant tissue, to assist with finding the macroinvertebrates, so we can pick through samples once and be much more certain all the macroinvertebrates have been located. White sucker fish were found caught in at least two of the rock bags in 2012, entangled in the fabric mesh. Using a commercially available sampler with thicker mesh rope, or constructing one using sturdier mesh, might prevent such entanglements in the future.

References:

Davies, Susan P. and Leonidas Tsomides. Methods for Biological Sampling and Analysis of Maine's Rivers and Streams. Maine Department of Environmental Protection publication # DEP LW0387-B2002. August, 2002.

Blockson, Karen A. A Review of Biological Assessment Tools and Biocriteria for Streams and Rivers in New England States. US Environmental Protection Agency publication # EPA/600/R-04/168 October 2004.

Novak, M. A. and R. W. Bode. Percent Model Affinity: A New Measure of Macroinvertebrate Community Composition. Journal of the North American Benthological Society, Vol. 11, No. 1 (Mar., 1992), pp. 80-85 Article Stable URL: http://www.jstor.org/stable/1467884

Merritt, R.W., K.W. Cummins, and M.B. Berg. An Introduction to the Aquatic Insects of North America, 4th Edition. Kendall Hunt, 2008.

Nitrates in Runoff

What: Measuring NH4+, N03- in soil pore water, or the runoff from the upland that sinks into the soil as it approaches the stream bank, gives a sense of what nutrients are reaching the stream due to upland land use.

Where: At all study sites in 2011-2012: 1,2,3,4,5,7,8,9,10 and 11. Note that there is no site 6, but there is a total of 10 paired study sites.

How: Levels of inorganic nitrogen in soil pore water were assessed using samplers buried in the stream bank within the apparent path of water flow from the upland habitat. Samplers hold resin beads (Mixed Bed Exchange Resin, IONAC ® NM-60 H+/OH- Form, Type I, Beads (16-50 Mesh), available from J.T. Baker, #4631-01) which exchange ions with water that flows by them, mimicking the action of plant roots taking up nutrients. Resin beads were placed inside a "knee-high" ladies' stocking sterilized with 0.3M HCl, with a PVC ring for structural support (Penn State, Theodose). Samplers were deployed for 53 to 83 days before being collected and processed. The two-day processing procedure (Hoskins) involves extraction of nitrates from the resin beads using KCl with agitation followed by next-day filtration after nitrates are mobilized into solution. Samples of the liquid extract are sent away to another laboratory for analysis, and we recieve a report of [NH4+] and [NO3-] for each site.

Pros / Cons / Recommendations: Many previous applications of this sampling method were in wetland soils, particularly salt marshes. We learned that the samplers could be deployed for much longer periods in drier, upland soils without the resin beads becoming saturated. Further analysis of data from years two and three is needed to determine whether the nitrogen levels detected by these samplers are indeed correlated with upland land use in the MBLR watershed, as hypothesized. Contact Terry Theodose at USM and Pam Morgan at UNE for more information or assistance with these sampling methods or related literature.

References:
Penn State College of Agricultural Sciences. "Measuring Nitrate Leaching with Resin Bags". Available at http://plantscience.psu.edu/research/labs/roots/methods/field-methods/measuring-nitrate-leaching-with-resin-bags. Access date 16 August 2012, last updated 2010.
Theodose, Terry. "Resin bag preparation". Theodose Lab in-house publication.
Hoskins, Bruce. "KCl extraction of resin bags". University of Southern Maine Soil Science Lab in-house publication.

MBLR Ecosystem Research:
Changes to Project Proposal as of July 10th, 2012.

Resin bags used to measure nitrogen in runoff in paired buffered and non-buffered sites were deployed for approximately two months, from mid-July to mid-September. Colleagues including Terry Theodose at the

University of Southern Maine and Pam Morgan at the University of New England have used these samplers in wet salt marsh soils, deploying the resin bag for a maximum of one month, but in the dry soils of the MBLR watershed, the nutrient collector beads inside the resin bag do not become saturated as quickly, so deploying for longer periods will work (Michele Dionne, personal communication, 18 June 2012).

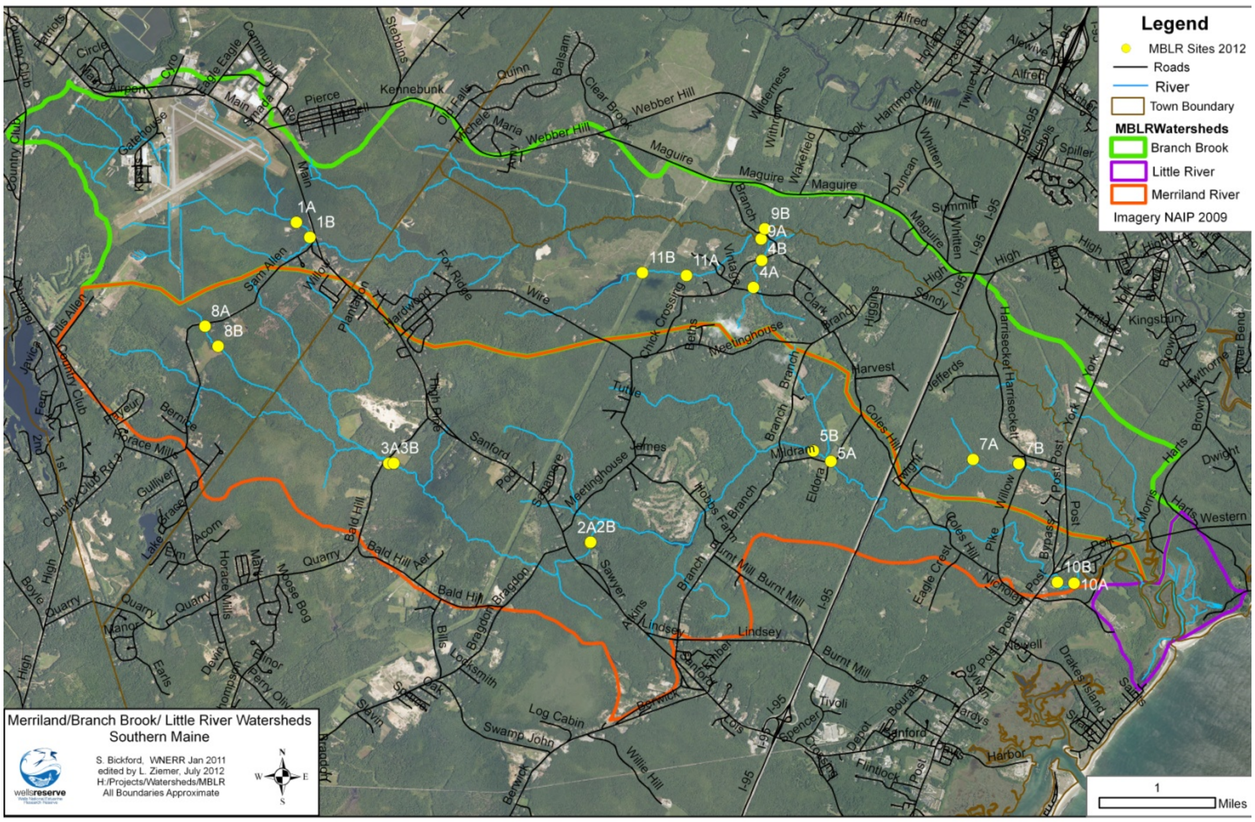
The epibenthic algae sampling method was changed from Tom Danielson's method, which we used in 2011, because the protocol we were using during the first field season was designed for cobble-bottom streams, and most of our sites have sandy substrates. The original protocol was chosen before our study sites were finalized, so we did not know that the majority of sites would be so sandy. In 2012, we are using unglazed ceramic tiles glued to bricks, which are placed in the stream for approximately two weeks. We decided upon this method based on a conversation with Dave Burdick and Chris Peter (University of New Hampshire's Jackson Estuarine Laboratory) on June 25th, 2012. Laboratory methods for processing the algae collected from tiles will be based on protocols used by SWMP technicians.

In summer 2011, we fabricated a viewing bucket using a plastic storage container, epoxy, and a sheet of Plexiglas. The bottom of the storage container was cut out with a utility knife, leaving a lip where the Plexiglas could be glued to the container. The clear viewing area was approximately 26x18". 35 dots were placed (using white-out) in a regular grid of 35 dots with 4 cm between each dot, 7 dots wide, and 5 dots high. This method was based almost exactly on one developed by Tom Danielson at the Maine DEP.

In early summer 2011, Michele Dionne consulted with Leon Tsomides at the Maine DEP regarding macroinvertebrate methods and taxonomy. The DEP conducts regulatory-level sampling of benthic macroinvertebrates and epiphytic / epibenthic algae all over the state. The level of taxonomic resolution required to submit data from this project to the DEP's database was not possible with the available funds for this project, so we selected a macroinvertebrate IBI that was based on family-level identification, which requires less training and could be done in-house, and, in 2012, a algae protocol based on chlorophyll analysis, something we already do in the lab here. This plan has the added benefit of allowing us to assure landowners that the data we're collecting will not be used for regulatory purposes.

Water quality loggers were used to sample at all study sites, not only the six where electro fishing, habitat surveys, and macroinvertebrate and periphyton survey will be performed. The loggers are deployed once per field season (summer) at each site, not three times (spring, summer, fall). In the 2012 season so far, deployment periods have lasted two days, and may be slightly less than 48 hours depending when vehicles and personnel are available.

Merriland River, Branch Brook and Little River Site Locations for Sustaining Coastal Landscapes and Community Benefits Ecological Research



Fish Species
Sampled with electrofishing
2011
Jacob Aman, Wells NERR
Research Associate

Branch Brook

Salvelinus fontinalis	Brook Trout
Anguilla rostrata	American Eel
Notropis cornutus	Common Shiner
Catostomus commersoni	White Sucker
Ictalurus nebulosus	Brown Bullhead

Merriland River

Salvelinus fontinalis	Brook Trout
Anguilla rostrata	American Eel
Esox niger	Chain Pickerel
Lepomis gibbosus	Pumpkinseed
Catostomus commersoni	White Sucker
Salmo trutta	Brown Trout

Stream Habitat Assessment Protocol

NERRS Science Collaborative Project: Sustaining Coastal Landscapes and Community Benefits
Merriland River and Branch Brook, Sanford, Kennebunk and Wells, Maine
Wells National Estuarine Research Reserve (Wells NERR)
Created: 2011

Updated: 2012

Equipment Checklist:

☐ Data sheets
☐ 2 Clipboards
(not including e-fishing clipboard)
☐ Protocol
☐ Pencils
☐ 2 Meter sticks
☐ 2 Calculators
☐ Camera
☐ Waders
☐ Bug spray
☐ Sunscreen
☐ First Aid Kit
☐ 2 Measuring tapes (at least 200')
☐ Flagging and Flags
☐ 2 Thermometers (ºC)
☐ Hand Level
☐ 2 Stadia rods
☐ Clinometer
☐ GPS unit
☐ Flow meter- pole and meter
☐ Stakes (to fasten meter tape to bank)
☐ Range finder
☐ YSI DO/temp meter
☐ pH meter
☐ Sediment scoop
☐ 4 Buckets

FIELD DATA SHEET 1:

1. **Identify Stream Reach:**

Identify 200' stream reach. Flag upstream and downstream ends.
Start the assessment at the DOWNSTREAM end of the reach.

2. **<u>Site ID</u>, <u>Stream name</u>, <u>Date</u>, <u>Time</u>, <u>Personnel</u>**

Mark the Site ID and Date at the top of each data sheet.

***<u>Note on Units</u>:**

Most field measurements are easier to record in meters. When entered on the computer, the data will be automatically converted to standard units (inches). Certain measurements must be recorded in standard units as indicated below.

Metric Units (m, cm)	Standard Units (ft, in)
Everything else	Stream reach (200 ft) Bank drop (because the stadia rods used in this survey are only marked in ft and in)

3. **<u>Downstream Channel variables</u>:**
    a. **Channel width:** Measure the <u>bankfull width</u> (the width of the stream when the water is at its high flow stage, beyond which water would overflow into the floodplain). Indicators of bankfull width include:
        - change from steep bank to horizontal surface
        - bank undercuts
        - areas of deposition (sand, woody debris, etc.. deposited by high flows)
        - change in vegetation (look for limit of perennial woody vegetation)
    b. **Wet width:** the width of the water surface

c. **Depth @ ¼, ½, ¾ CW:** Stretch a meter tape across the stream and use a meter stick to measure the depths.
d. **Water temperature (ºC)**: use the YSI multimeter to measure temperature
e. **DO:** dissolved oxygen (see YSI multimeter SOP for details)
f. **pH:** (see pH meter SOP for details)
g. **Time, Air Temp (ºC)**

4. <u>**Upstream Channel Variables**</u>: same as for downstream

5. <u>**Flow**</u>**:**
Establish a transect perpendicular to stream flow across the stream by stretching the measuring tape across the downstream end of the reach (or nearby).
Hold or secure the measuring tape <u>at wet width</u>. Begin at the left bank and move right. (Refer to flow meter SOP for details.)
   a. If the stream is less than 13ft (~4.0 m) wide, take flow measurements at ¼, ½, and ¾ wet width.
   b. If the stream is greater than 13 ft (~4.0 m) wide, take a flow measurement every 3 ft (~90 cm).
   c. In spots where the depth is less than 2.5 feet (76 cm), take one 20-second measurement at 0.6x stream depth.
   d. Where the water is deeper than 2.5 feet (76 cm), take one 20-second measurement each at 0.2x and 0.8x stream depth and average the 2 values for water velocity at that spot.

6. <u>**Spawning Gravel Residential**</u>**:**
   a. Record beds that contain gravel <u>between ¼ and 3 inches</u> in diameter in the "Spawn Gravel Residential" table.
   b. **Length:** measure the length of the gravel bed
   c. **Width:** choose a spot that represents the average width of the gravel bed
   d. **Area:** length x width
   e. **Embedded (E) or Not (N):**
      i. <u>Embedded</u> = buried up to at least ¼ of the rock's diameter in fines or sand

7. <u>**Spawning Gravel Anadromous**</u>**:**
   a. Record beds that contain gravel <u>between ¼ and 6 inches</u> in diameter in the "Spawn Gravel Anadromous" table.
   b. Measure as with residential gravel

8. <u>**Tributaries**</u>**:**
   a. **ID/Waypoint:** mark the GPS coordinates (UTM) of the tributary
   b. **Right/Left:** indicate whether the tributary is on the right or left bank
   c. **Perennial/Intermittent:**
      i. <u>Perennial</u> = stream contains flowing water year-round
      ii. <u>Intermittent</u> = stream ceases to flow for part of the year

9. **Seeps:** groundwater from the bank that flows into the stream
    a. **ID/Waypoint:** mark the GPS coordinates (UTM) of the seep
    b. **Right/Left:** indicate if the seep is on the right or left bank

10. **Erosion Sites:** actively or recently eroding/collapsing banks; characteristics include: exposed soils and rocks, evidence of tension cracks, active sloughing
    a. **ID/Waypoint:** mark the GPS coordinates (UTM) of the site
    b. **Right/Left:** indicate if the site is on the right or left bank

Migration Barriers (11 - 15):

11. **Falls/cascades:**
    a. **Height, Wet Width**
    b. **Gradient:** measure using clinometer method as in bank gradient (below)

12. **Dams: Length, Width, Height**

13. **Chutes:** newly-formed, narrow, confined auxiliary channels for transporting high-velocity flows; chutes only move water intermittently at high flows (do not confuse with a cutoff channel, which moves water almost all the time and cuts off a meander bend)
    a. **Height**, **Width, Length**
    b. **Gradient:** measure using clinometer method as in bank gradient (below)

14. **Beaver Dams:**
    a. **Height, Width**
    b. **Active or Inactive:** signs of beaver activity include gnawed or toppled trees and newly added branches

15. **Culverts:**
    a. **Type:** R = round, S = square, A = squashed arch, B = bottomless arch
    b. **Length, Width, Height**
    c. **Gradient:** measure using clinometer method as in bank gradient (below)
    d. **Jumping distance:** distance between the bottom of culvert's outlet and the water's surface
    e. **Spill pool depth:** spill pools are areas of deeper water caused by erosion from fast flows leaving the outlet of the culvert
    f. **Baffles present?:** baffles are a series of barriers installed to slow the velocity of the water
    g. **Migration barrier?:** mark "yes" if the culvert may obstruct the passage of migrating fish

<u>Aquatic Vegetation, Canopy, Overall Substrate Type, Riparian Vegetation (16, 18, 20, 21)</u>:

Estimate the percentage of the habitat occupied by each category and circle the corresponding number:

0 = 0%
1 = 1 – 20%
2 = 20 – 40%
3 = 40 – 60%
4 = 60 – 80%
5 = 80 – 100%

16. <u>Aquatic Vegetation</u>: aquatic vegetation refers to plants that generally grow in water, not terrestrial plants that have been submerged

- **a.** <u>Emergent</u> = part of the plant sticks up out of the water
  <u>Submerged</u> = all of the plant is underwater
- **b.** Estimate the percentage of each category of aquatic vegetation (emergent, submerged) within the stream channel and circle the corresponding number as indicated above.

17. <u>Bank Condition</u>: select the number that best describes the bank condition for each bank (left and right):

1 = Stable, little sloughing or scouring
2 = Moderately stable, some sloughing or scouring
3 = Unstable, bank slides, new bank sloughing or erosion
4 = Undercut banks, moderately stable

18. <u>Canopy</u>: for each bank (left and right), estimate the percentage cover of tree canopy over the land within 50 feet of the stream and circle the corresponding number as indicated above.

19. <u>Access</u>: circle whether the stream reach is accessed from the left or right bank and select the number that best describes the means of access:

1 = Foot access - road within 100 yds of stream
2 = Foot access - road within 100 yds to 1/4 mi of stream
3 = Four wheeler access
4 = Standard vehicle access
5 = No foot access - road too far from stream
6 = Inaccessible - rough terrain, posted land, etc…

20. <u>Overall Substrate Type</u>:

- **a.** Estimate the percentage of each category of substrate (bedrock, boulders, rubble, gravel, sand, fines) within the stream channel and circle the corresponding number as indicated above.
  <u>Fines</u> = clay or silt (finer than sand)

21. <u>Riparian Vegetation</u>:

a. <u>Riparian area</u> = the land within 50 feet of the stream channel

b. For each bank (left and right), estimate the percentage of each category of vegetation (trees, shrubs, grasses, lawn, rock, soil, pasture, understory/herbaceous, other) within 50 feet of the stream channel and circle the corresponding number as indicated above. If "other" please describe.

22. <u>Large Woody Debris</u>:

a. Mark logs and other woody debris that meet the following requirements:
- logs 8" diameter and 8' long OR 8" diameter and embedded
- logs must be at least partially below the high water line (for normal yearly flows) of the channel

b. ID: assign an ID to each piece of debris as follows: siteW#

e.g. the second woody debris at site 8A has the following ID: 8AW2

c. Waypoints: mark the GPS coordinates (UTM) of the woody debris

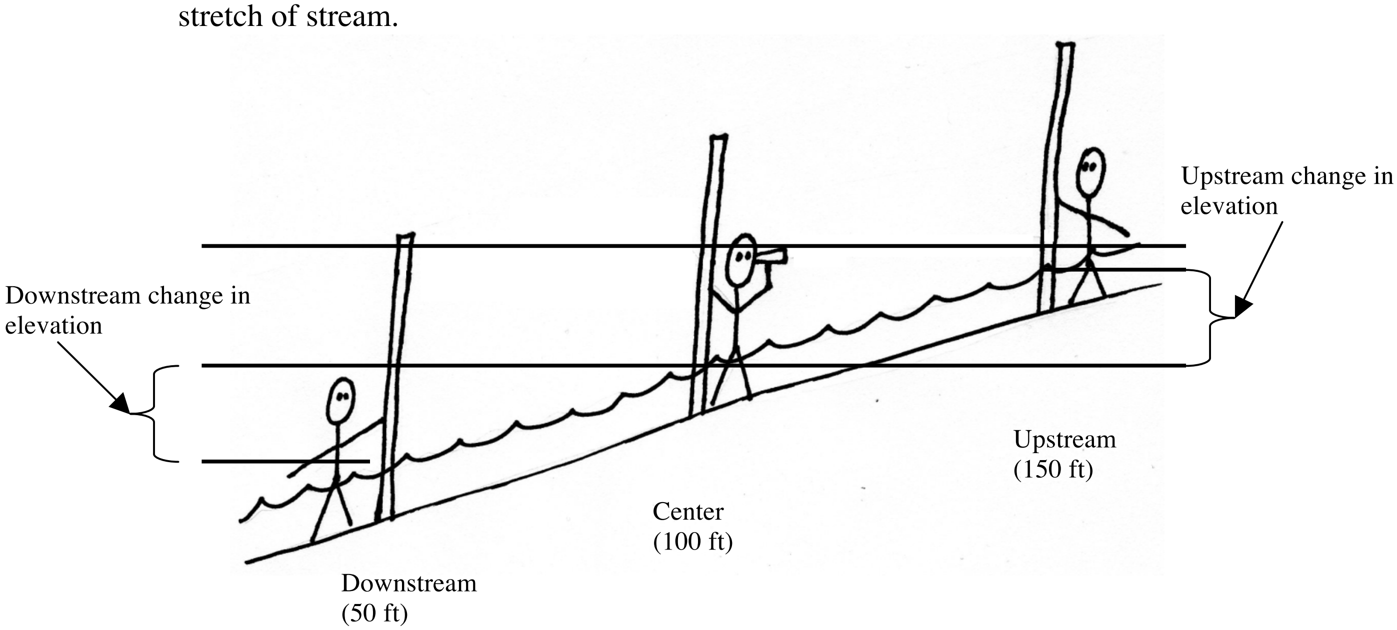
d. Embedded (E) or Not (N):

<u>Embedded</u> = partly buried in the stream bottom

e. Mark the location of the woody debris on the site sketch.

23. <u>Stream Gradient (%)</u>:

Use the table provided in the data sheet to record eye level and water depth from each position. This will aid in calculating the change in elevation over the 100 ft stretch of stream.



a. Upstream change in elevation:

One person will stand at the 100 ft mark (halfway down the stream reach). A second person will stand upstream at the 150 ft mark. Both people will stand in the deepest part of the channel facing each other and record the water depth at that spot. The person at the 100 ft mark will record his eye height on his stadia rod then look through the hand level and record the height at which his eye level meets the second person's stadia rod.

Subtract the water depth from the eye level for each position. The difference between the center and the upstream values is the change in elevation over that 50 foot stretch. (See calculation table in data sheet.)

b. **Downstream change in elevation:** calculate as with upstream change in elevation.
c. **Total change in elevation:** downstream change in elevation + upstream change in elevation (record in inches)
d. **% change over 1200':** total change in elevation/1200' x 100

24. <u>Bank</u>: Perform the following measurements for both the left and right banks.

a. Find an area with a bank gradient representative of the overall stream reach. If the gradient changes dramatically throughout the reach, more than one measurement may be taken.
b. **Drop:** Stand in the deepest part of the channel with a stadia rod and estimate the vertical distance from the bottom of the channel to the top of the bank.
c. **Gradient (%) to stream bed:** One person will stand in the deepest part of the channel at the selected location and face the stream bank. A second person will stand 50 feet away, up the bank. The first person will choose a measurement at eye height on his stadia rod and the second person will place a hand at the identical point on her stadia rod. The first person will look through a clinometer and line the tick mark up with the second person's hand to get a measurement of stream gradient. (See clinometer SOP for details.)
d. **Gradient (%) to top of bank:** Repeat the measurement taken in step "c" but the first person will stand on the edge of the bank rather than in the channel and the second person will back up so that there are still 50 feet between them.

25. <u>Comments</u>: include any additional information not otherwise recorded on the data sheets such as:

- Changes in protocol
- Observations
- Conditions
- Recent storm events and rainfall
- Noticeable odor, color, foam or other water conditions
- Human impacts not otherwise noted (e.g. garbage, swimming, etc…)

FIELD DATA SHEET 2:

Substrate Key:
L = Land
K = Bedrock
B = Boulder - bigger than a basketball
(>12")
R = Rubble - tennis ball to basketball
(6-12")
G = Gravel - peppercorn to tennis ball
(1/4-6")
S = Sand - salt to peppercorn
(granular <1/4")
F = Fines - finer than salt
(clay and silt)

1. **<u>Pools</u>:** areas of low flow with unbroken surface; depth greater than that of rifle
    b. **Length**
    c. **Width:** choose a spot that represents the average width of the stream
    d. **Depth (1,2,3):** choose three spots of approximately average depth
    e. **Mean Depth:** average the three depth values recorded above
    f. **Dominant Substrate:** select the one substrate type that dominates the stream bottom within the pool
    g. **Embeddedness:** decide whether the substrate is embedded **(E)** or Not **(N)**
        i. <u>Embedded</u> = buried up to at least ¼ of the rock's diameter in fines or sand
    h. **Subdominant Substrate:** select the second most dominant substrate type
    i. **Cover/Shelter:**
    Abundant = more than ½ of the perimeter of the pool has cover/shelter
    Intermediate = ¼ - ½ of the perimeter of the pool has cover/shelter
    Exposed = less than ¼ of the perimeter of the pool has cover/shelter
    j. **Dissolved Oxygen (%), Dissolved Oxygen (mg/L), Temperature (ºC)**

2. **<u>Riffles</u>:** surface broken by substrate as water moves over it (do not record riffles caused by temporary debris jams that easily wash away)
    k. **Length, Width, Dominant Substrate, Embeddedness, Subdominant Substrate** (measure and record as with pools above)

3. **<u>Runs</u>:** smooth-moving water
    l. **Length, Width, Dominant Substrate, Embeddedness, Subdominant Substrate** (measure and record as with pools above)

SUBSTRATE MAP WORKSHEET:

1. **Mark Transects:** walk five substrate transects in the 200 ft stream reach at 20, 60, 100, 140 and 180 ft from the downstream end of the reach. Mark the transects with flagging.
2. **<u>Transect #</u>:** Reach ID, ST for "Stream Transect," distance from downstream end of reach
    Example: Site 1A stream transect at 20 ft = 1AST20
3. **<u>CW</u>:** Measure the channel width at the transect
4. **<u>Wet Width</u>:** Measure the wet width of the transect
5. **<u>Depth at ¼ CW</u>:** Depth at ¼ of the channel width
6. **<u>Depth at ½ CW</u>:** Depth at ½ of the channel width
7. **<u>Depth at ¾ CW</u>:** Depth at ¾ of the channel width
8. **<u>Substrate Type</u>:** Stretch the meter tape across the channel (at channel width). Working from the left bank to the right bank, record each substrate type and where it begins and ends on the meter tape. Each substrate type along the transect should be entered as a separate row on the data sheet. Multiple letters (up to three) may be used to indicate co-occurring substrate types with the more dominant substrates coming first (e.g. RGS = rubble, gravel, sand). See substrate key on page 7 for letter codes.

Example Substrate Transect (Site 3B transect at 20 ft):

ROUGH SKETCH OF STREAM REACH:

Make a rough sketch of the stream reach including pools, riffles, runs, tributaries, seeps, LWD, etc…

Transect #	CW(m)	Wet Width (m)	Depth at ¼ CW	Depth at ½ CW	Depth at ¾ CW	Substrate type	Substrate starting poing	Substrate ending poing	Distance covered by substrate (m)
3BST20	9.4	5.4	0.68	0.27	0	F	0	1	1
						SF	1	2.6	1.6
						F	2.6	5.4	2.8
						L	5.4	9.4	4.0

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